Horological Disquisitions

Concerning the

NATURE of TIME,

AND THE

Reasons why all Days, from Noon to Noon, are not alike Twenty Four Hours long.

In which appears the Impossibility of a Clock's being always kept exactly true to the Sun.

With TABLES of EQUATION, and Newer and Better RULES than any yet extant, how thereby precisely to adjust ROYAL PENDULUMS, and keep them afterwards, as near as possible to the apparent Time.

With a TABLE of PENDULUMS, shewing the BEATS that any Length makes in an Hour.

A Work very necessay for all that would understand the true way of rightly managing Clocks and Watches.

By *JOHN SMITH*, C.M.

To which is added,

The best Rules for the Ordering and Use both of the Quick-Silver and Spirit Weather-Glasses: And Mr. *S. Watson*'s Rules for adjusting a Clock by the *Fixed Stars*.

LONDON: Printed for *Richard Cumberland* at the *Angel* in *S.* Paul's *Church-Yard*. 1694.

Licensed,

January 17.
1694.

D. Poplar.

TO THE READER.

THE Design of these Papers is not to cover the Clock-Makers *Imperfections, as some have suggested, but plainly to demonstrate the true Reason of those unavoidable Variations between the Time given by the Sun and that of a good and well-adjusted Clock; and to give such Directions as may yet reduce them to a nearer Agreement in Time: In doing of which I have endeavoured to express my self in such Words as I thought most proper to inform the Reader's Understanding. What is here exposed to publick View is not the Result of mere Speculation, but of Skill and Pra-*

ctice, for as it has been my Profession, so it has been my Care and Concern also to understand exactly not only the Nature of a Clock, but that also of its Motion, and the Result of my Discoveries: As to the latter, you have very briefly laid down in the following Discourse; and I assure you that I have not spoken any thing of the Truth of which I was not first well satisfied.

The Style indeed is purely Mechanick, *but this is no Argument against its usefulness, since in Books Men ought not so much to heed who 'tis that speaks as what is spoken. He always writes best that from his own Knowledge and Experience can inform the World of something that's advantagious to Human Life, which was not known to Mankind in the Times before.*

Farewel.

A Table of Equations,

Shewing the true Length of every *Natural-Day*, or the Seconds of Time that they are either Longer or ſhorter than XXIV. Hours.

By JOHN SMITH C.M.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Octo.	Nov.	Dec.
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
1	24	D 24	17	17	3	11	7	9	20	14	9	29
2	23	2	17	16	3	11	7	9	20	14	10	30
3	22	2	18	16	1	12	7	9	21	13	10	30
4	21	4	18	15	D 24	12	6	11	21	13	10	30
5		4	18	15	D 24	12	6	12	21	13	11	30
6	20	4	18	14	1	13	6	13	21	13	12	30
7	19	5	18	14	2	13	6	13	22	13	12	30
8	18	5	18	14	2	13	5	14	22	11	13	30
9	17	6	18	14	3	13	4	14	22	10	15	30
10	16	8	18	13	3	13	4	15	21	9	17	30
11	16	8	18	13	3	13	3	15	21	8	17	33
12	16	9	18	12	4	13	2	15	20	7	18	30
13	16	9	19	12	4	13	2	16	20	7	18	30
14	16	10	19	11	5	13	1	16	20	6	19	31
15	15	10	20	11	5	13	D 24	17	20	6	20	31
16	14	11	20	10	6	12	D 24	17	20	5	21	31
17	13	12	20	10	6	12	1	17	20	4	22	31
18	12	13	20	10	6	11	2	18	20	3	23	30
19	11	13	20	10	6	11	3	18	19	3	23	30
20		13	19	10	7	11	4	19	19	2	24	30
21	10	14	19	9	8	11	4	19	19	1	24	30
22	9	14	19	7	8	10	4	19	19	D 24	24	30
23	8	15	19	7	9	10	4	19	19	D 24	25	30
24	6	15	19	7	10	10	5	19	18	1	25	30
25	5	15	19	6	10		5	19	17	2	25	28
26	4	15	19	5	11	10	5	20	17	2	25	23
29	3	16	19	5	11	9	5	20	16	3	26	23
28	3	17	19	5	11	9	6	20	16	4	26	27
29	2		19	5	11	9	7	20	16	6	27	27
30	1		18	4	11	8	8	20	15	7	28	25
31	D 24		17	4	11		9			8		24

The Character D 24, ſhews what Days are truly 24 Hours long, the *Red Figures* ſhew the *Seconds of Time*, that thoſe Days on which they are plac'd are longer than 24 Hours, and the *Black Ones* ſhew how many *Seconds* thoſe Days are ſhorter than 24 Hours: And here you are to note, That in thoſe parts of the *Year* where days are above 24 Hours long, there a well adjuſted Clock will gain, becauſe the *Pendulum-Day*, which is the 24 Hours, of its own Motion will be finiſh'd before the *Natural-Day* is ended. On the contrary, Where the *Days* are leſs in length than 24 Hours, there the Clock will loſe, or go too ſlow, becauſe the *Pendulum-Day* will not be ended ſo ſoon as the *Natural* one.

London: Printed for R. Cumberland, at the *Angel* in S. Paul's *Church-Yard*.

A Second Table of Equations,

Shewing how to order a well-adjusted Clock, so as that the whole Year round it shall not differ above the Sixteenth Part of an Hour from the Sun, or 3′ 45″.

By JOHN SMITH, C.M.

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Octo.		Nov.		Dec.	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1	7⊕	8	2	49	1	40	3	28	1	48		59	1	34	1	28		20	2	5		34	2	43
2	3	21	2	49	1	57	3	11	1	51	1	00	1	41	1	19		00	2	19		43	3	12
3	2	58	2	47	2	14	2	55	1	54	1	11	1	48	1	10		20	2	33		53	7⊕	28
4	2	35	2	45	2	32	2	39	1	55	5⊕	8	1	55	1	1		41	2	46	1	3	3	15
5	2	13	2	41	2	50	2	24	1	55	3	33	2	1		50	1	2	2	59	1	13	2	45
6	1	52	2	37	3	8	2	9	1	55	3	11	2	7		38	1	23	3	12		24	2	15
7	1	32	2	33	3	26	1	55	1	54	2	58	2	13		25	1	44	3	25	1	36	1	45
8	1	13	2	28	7⊕	29	1	41	1	52	2	45	2	19		12	2	6	5⊕	10	1	48	1	15
9		55	2	23	3	27	1	27	1	50	2	32	2	24		2	2	28	1	11	2	1		45
10		38	2	17	3	9	1	13	1	47	2	19	2	28		16	2	50	1	1	2	16		15
11		22	2	9	2	51	1	0	1	44	2	6	2	32		31	3	11		52	2	33		15
12		6	2	1	2	33		47	1	41	1	53	2	35		46	7⊕	17		44	2	50		45
13		10	1	52	2	15		35	1	37	1	40	2	37	1	1	3	25		37	3	8	1	15
14		26	1	43	1	56		23	1	33	1	27	2	39	1	17	3	5		30	3	26	1	45
15		42	1	33	1	37		12	1	28	1	14		40	1	33	2	45		23	7⊕	20	2	16
16		57	1	23	1	17		1	1	23	1	1	2	40	1	50	2	25		18	3	25	2	47
17	1	1	1	12		57		9	1	17		49	2	40	2	7	2	5		13	3	4	7⊕	3
18	1	24	1	00		37		19	1	11		37	2	39	2	24	1	45		9	2	42	3	14
19	1	36		47		17		29	1	5		26	2	37	2	42	1	25		6	2	19	2	44
20	1	47		34		3		39		59		15	2	34	3	00	1	9		3	1	56	2	14
21	1	58		21		22		49		52		4	2	30	3	19		47		1	1	32	1	44
22	2	8		7		41		58		44		7	2	26	7⊕	23		28		1	1	8	1	14
23	2	17		7	1	00	1	5		36		18	2	22	3	26		9		1		44		44
24	2	25		22	1	19	1	12		27		28	2	18	3	7		10		1		19		14
25	2	31		37	1	38	1	19		17		38	2	13	2	48		28				6		16
26	2	36		52	1	57	1	25		7		48	2	8	2	29		45		4		31		41
27	2	40	1	7	2	16	1	30		4		58	2	3	2	9	1	2		6		56	1	12
28	2	43	1	23	2	35	1	35		15	1	8	1	58	1	44	1	18		9	1	22	1	40
29	2	46			2	54	1	40		26	1	17	1	52	1	29	1	34		13	1	48	2	7
30	2	48			3	13	1	44		37	1	26	1	45	1	00	1	50		19	2	15	2	34
31	2	49			7⊕	16				48			1	37		40				25			2	59

Note, the *Day* on which this Mark ⊕ is plac'd, are *Rectifying Days*; on any Day then that is not a *Rectifying-Day*, let the Clock be *Set* so much too Slow as the *Black*, or so much too Fast as the *Red Figures* express, and so let him go on till a *Rectifying-Day*, on which let Him be *Set* backward if the Figures on the *Rectifying-Day* are *Black*, or forward if the Figures are *Red*; just so many *Minutes* and *Seconds* as the sum of *Figures* are on the *Rectifying-Day*, and continue so to do each *Rectifying-Day* following: and then the Clock in the Intermediate Spaces between will agree with the *Sun*, as the Figures in the *Table* express, that is will be either so much too Fast, or so much too Slow.

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Horological Diſquiſitions.

AS Time, that little part of Eternity, in which the Sun ſhall continue to run his Race, is divided naturally into Years and Days, by the Two different Motions of that luminous Body; ſo Mankind has by Divine Direction, been induc'd to divide the Day into yet leſſer Parts, called Hours and Minutes; and as the exceeding great Uſe and Benefit thereof is now known to many Nations, ſo in the moſt civilized Parts of the World Men have been ſtill contriving Ways how to do this with the greateſt Exactneſs.

The firſt and moſt ancient of all was doubtleſs that of Sun-Dials; a noble Invention, but yet defective, in that it is

of use no longer than the Sun shines: The next to this, of any value and Esteem, was that of the Hour-Glass; an excellent Contrivance, if its Usefulness at all Times be considered; but the Care required to keep it in continual Motion did still excite the Ingenious to endeavour the Discovery of something else that might not only be yet more exact, but free too from the continual Toil, as I may call it, and Trouble of Attendance.

In process of Time this came to be performed in part, by the way of Clock-Work; a Device first of all started among the *Germans*, from whom the Art of making Clocks dispersed it self over other Parts of *Europe*, but as yet Defective as to its exact and steady keeping of Time: At length, in *Holland*, an Ingenious and Learned Gentleman, Mr. *Christian Hugens*, by Name, found out the Way to regulate the uncertainty of its Motion by the Vibration of a Pendulum.

From *Holland*, the fame of this Invention soon past over into *England*, where several eminent and ingenious Workmen applyed themselves to rectify some

ſome Defects which as yet was found therein; among which that eminent and well-known Artiſt Mr. *William Clement*, had at laſt the good Fortune to give it the finiſhing Stroke, he being indeed the real Contriver of that curious kind of long Pendulum, which is at this Day ſo univerſally in uſe among us.

An Invention that exceeds all others yet known, as to the Exactneſs and Steadineſs of its Motion, which proceeds from Two Properties, peculiar to this Pendulum: The one is the weightineſs of its Bob, and the other the little Compaſs in which it plays: The firſt of theſe makes it leſs apt to be commanded by thoſe accidental differences of Strength that may ſometimes happen in the Draught of the Wheels, and the other renders the Vibrations more equal and exact, as not being capable of altering ſo much in the diſtance of its Swinge, as thoſe other kind of Pendulums are, who fetch a larger, and, by conſequence, a leſs conſtant Compaſs.

For Pendulums that ſwing or vibrate very far out, as all Crown-Wheel Pendulums do, are apt, by reaſon of many Accidents that happen to vary much in the Diſtance, they ſwing, and that's the reaſon they do not always go or move the ſame Pace, a larger Vibration taking up more Time to be performed in, than leſſer ones do: But the Vibrations of this Pendulum of Mr. *Clement*'s contrivance is ſo very exact and ſteady, that, when 'tis well in Order, and the Air of the ſame Conſiſtence, it ſhall in Five hundred or a Thouſand Revolutions of its Index, keep ſo equal a Time, that no Human Art can diſcover the leaſt conſiderable Difference in any of its Revolutions, an excellence to which no other known Motion can as yet pretend, and for which I think it will not be improper now, at laſt, to call it the *Royal Pendulum.*

But although the Motion thereof be ſo very curiouſly exact and equal, yet 'twill not for all that regulate the Motion of a Clock in ſuch a manner as that the Index or Hand ſhall continually agree with that Time which the Sun gives; for

for by conſtant Experience we find, that the beſt of Clocks, when exactly adjuſted, will yet be found in ſome conſiderable Time of going to be either too faſt or too ſlow for the Sun, although it was at the firſt ſet right therewith.

Now this Diſagreement cannot be occaſioned by any Defect proper to the Motion of the Pendulum, each Twenty Four Hours; of which, when well rectified, being the ſame for length of Time, but it does proceed from an irregularity in the Sun's apparent Motion, which does occaſion great diverſity in the Lengths of Natural Days. 'Tis generally believed indeed that the natural Day, or the Time between 12. and 12. a Clock, is always in length juſt 24. Hours: But this is a great Miſtake, for it will appear by the following Accounts of it, that it is but in ſome Parts of the Year that the Days are ſo; in all the other Parts, between theſe, they are found continually to differ, being ſometimes above 24. Hours long, and ſometimes leſs than 24. Hours; and though the Differences may ſeem but a ſmall matter to ſome, the greateſt exceſs

being not above half a Minute, yet if theſe, ſeemingly but little Differences, be added together for the ſpace of a Month or Two together, they will amount to a very conſiderable Sum of Time.

Now, to make the reaſon of this irregular Length of Days as plain as I can, be pleaſed to take notice, That as Natural Days are that ſpace of Time in which the Sun (or, as others think, the Earth) by the Motion of thoſe Orbs, that divide Time into Days, is moved round juſt one whole diurnal Revolution, or paſſes from the Meridian, or Twelve a Clock Point of one Day to that of the next; ſo it muſt follow that all ſuch natural Days cannot be of a true and equal Length, unleſe the Sun, in that ſpace of Time does alſo move in ſuch a manner in his annual Orb, as that the Equinoctial may be always divided into equal Parts by thoſe Meridians, on which the Sun is upon each particular Day: But that this is not done, is plain to all that are verſt in Aſtronomy, and rightly underſtands the Uſe of the Globe.

This,

This, an exact Table of the Sun's Right Aſcenſions does demonſtrate, for by that 'twill be found that the Meridian Sun of each Day doth not divide the Equinoctial into equal parts, their Differences not being equal, but more on ſome Days than they are on others; and theſe their Differences will appear yet more plain and viſible, if you will be but at the Pains to compute what the Right Aſcenſions amount to in 10 or 20 Days Time, in ſome parts of the Year, and compare that with thoſe of the like Number of Days in ſome other part.

So alſo, if on the Globe you mark out on the Ecliptick 10 or 20 Days Motion of the Sun, as 'tis found ſet down in an exact Ephemeris or Almanack, that ſhews the Sun's true Place; and paſſing this under the brazen Meridian, note what number of Degrees on the Equinoctial are included in that Space, the which compare with thoſe of the like number of Days Motion in ſome other part of the Ecliptick, and the Degrees ſo compared will be found to differ, or be more in Number in ſome

Places than they are in others; which plainly demonſtrates the Thing aſſerted.

Now the Reaſon of theſe Differences in the Right Aſcenſions, and, by conſequence in the different Lengths of Days proceeds, in the Firſt Place, from the croſs Poſition of the Zodiack and the Equinoctial, which on Globes do repreſent the Circles of the Sun's yearly and dayly Motion; for the Courſe of the Sun's daily Motion being directly from Eaſt to Weſt, and the Circle of his yearly Motion being in poſition Croſsways thereunto from the almoſt South Weſt to the North Eaſt, as by the Globe is apparent, it follows that the Right Aſcenſion will be ſtill unequal; for 'tis impoſſible that the Sun, in his Motion, near *Aries* and *Libra*, where the Zodiack lyes croſs the Equinoctial, ſhould in any certain number of Days make the ſame Number of Degrees in Right Aſcenſion, as he will do near the two Tropicks of *Cancer* and *Capricorn*, where the Ecliptick runs in a manner parallel to the Equinoctial Circle.

And

And accordingly 'tis found by the beſt Tables of Right Aſcenſion, that the Right Aſcenſions belonging to 10 Days Motion of the Sun, near the Tropick of *Capricorn*, amounts to about 11 Degrees 30 Minutes, whereas that of the ſame Number of Days, near the Equinoctial Points of *Aries* or *Libra* will be found to be hardly 9 Degrees.

And as the Right Aſcenſions of the Tropicks differ from thoſe of the Equinoctial Parts of the Ecliptick, ſo the Right Aſcenſions of one Tropick differs from that of the other: Now the Cauſe of this differs from the Cauſe of the former unequalities, for this proceeds from the excentricity of the Centre of the Earth and the Centre of the Sun's yearly Orb; for the Centre of the Earth, on which we live, not being the ſame with the Centre of the Ecliptick, in which the Sun moves, but diſtant from it, as ſome Aſtronomers affirm, about 316000 Miles, it follows that there muſt be a greater part of the Sun's Orb on one Side of the Centre of the Earth than there is on the other; for which Reaſon, though the Sun moves

equally

equally each Day in the Circle of his yearly Courſe, yet to us he ſeems to move faſter in ſome Parts thereof than he does in others, and that makes the Right Aſcenſions greater near one Tropick than they are near the other.

And accordingly, by the Tables of the Sun's Motion 'tis found that he takes up but about 179 Days in paſſing that part of the Ecliptick between *Libra* and *Aries*, whereas between the Two Points of *Aries* and *Libra* he ſpends above 186, ſo that he is almoſt 7 Days more in paſſing the *Summer* half of the Ecliptick than he is in paſſing that of the *Winter*, and this ſeemingly ſwift and ſlow Motion of the Sun is the Cauſe that the Right Aſcenſions of 10 Days Motion near the *Winter* Tropick are 60 Minutes, or a whole Degree more than thoſe of the ſame Number of Days near that of the *Summer* one.

The Right Aſcenſions of 10 Days Time near the 2 Equinoctial Points do alſo differ ſomewhat; for thoſe of 10 Days Time, near *Aries*, are leſs by 30 Minutes than thoſe near *Libra*; the Reaſon of which is from hence, in that the

the Suns greateſt and neareſt Diſtance to the Earth, happens now in our Times to be about 8 Degrees and ſomething more from the Tropick Points, whereas had it fallen out exactly in the 2 Tropicks, then the Right Aſcenſions near the Two Equinoctials would have been both alike.

Now, by what has been ſaid, I hope the true Reaſon of the unequal Lengths of Natural Days will plainly appear, and by conſequence Men will not hereafter be ſo unreaſonably nice and curious, as ſome have heretofore been to expect always an exact Agreement between their Clocks and the Sun, for if there be from the Nature of the Fabrick of the World, and the Celeſtial Orbs above us, a neceſſity for thoſe Differences, as are found in the Sun's Right Aſcenſions, and there being for that Reaſon a Neceſſity alſo that the Days bounded thereby ſhould be unequal in proportion to thoſe Differences. Tis then plainly impoſſible that a Royal Pendulum (whoſe diurnal Revolutions are always equal, and, if well adjuſted, gives you the true Time of 24 Hours) ſhould agree

with

with the Sun, which makes the length of Days almoſt continually to differ, and to be ſometimes more than 24 Hours, and ſometimes leſs.

For, in the firſt Place, this makes it impoſſible to adjuſt a Clock well, barely by the Sun: For ſuppoſe one ſhould attempt to adjuſt a Clock when the Natural Days are not fully 24 Hours long, as about the middle of *March*, where, as appears by the firſt annexed Table, the Day wants 20″ of 24 Hours long, this Clock brought to go correſpondent to the Days in *March*, ſhall in *June* finiſh his Pendulum Day or his two 12 Hours Revolutions before the Sun ſhall compleatly paſs between one Meridian and another, that is, before the Sun ſhall paſs from the Hour of 12 one Day, to that of the Hour of 12 on the next, becauſe now the Natural Day is longer than 24 Hours by 13″, whereas the Day to which it was before adjuſted was 20″ ſhorter than 24 Hours, and by conſequence the Pendulum Day of the Clock muſt be finiſhed ſooner in *June* by 33″ than the Natural Day, and gain each Day 33 Seconds.

On

On the contrary, if a Clock could be adjuſted to the Sun in the Month of *December*, at which Time the Natural Day is longeſt, being then 31″, or half a Minute above 24 Hours in length, this Clock, when Natural Days are ſhorteſt, as in *March*, where they want 20″ of 24 Hours, this Clock, I ſay, ſhall not then finiſh his diurnal Revolutions in ſo little a Time as thoſe Days ſhall be accompliſhed, and by conſequence ſhall go each Day 50″ too ſlow, becauſe thoſe Days in *March* are ſhorter by 50″ than thoſe in *December*, to which your Clock is ſuppoſed to be adjuſted.

Suppoſed to be adjuſted, I ſay, for to do it exactly by the Sun, we affirm to be impoſſible, for the Length of Days continually altering, he that would adjuſt a Clock to the Sun muſt be always altering of it accordingly; and if he ſhould accidentally bring it to go ſlow enough, as he thinks, for ſome Days, ſuch as thoſe long ones in *December* are, the length of the Day ſoon altering, and becoming ſhorter, he muſt again alter the Length of his Pendulum, to make it go equal to Days that are now ſhorter,

and

and ſo not underſtanding the Nature of Time truly, nor of what Length a mean or middle Day is, he will, in Hopes of making it go always true, be continually altering of it, as he ſees it vary, and that without ever being ſo happy as to make it keep the Time deſired; for 'tis impoſſible a Motion that keeps always the ſame Time that its particular Length or pitch of Pendulum does admit of, can be ſo adjuſted by the bare Sun, as to accord therewith in all thoſe various lengths of Days, which are made by its either ſlow or ſwift Motion.

Since then things are thus, it remains that we ſhew, How by Art that may be done which by meer Natural Obſervation can never be effected; that is, by what means a Clock, regulated by a Royal Pendulum, may be adjuſted to ſuch a middle Pitch of Motion as to make in a compleat Year juſt 365 equal Revolutions, or ſo that each of its 24 Hours may be the ſame for Length, as the 365th part of a Year is, which is indeed the true Time of a 24 Hour Day, and that's the neareſt and the moſt exact pitch to which 'tis poſ-

ſible

ſible to adjuſt the beſt of Pendulums.

Now this is only to be done by the help of an exact Table of Equations, which ſhall as nearly as 'tis poſſible give you the true Length of every Day, ſo that knowing by this means not only which Days are truly 24 Hours long, but alſo which are ſhorter and which are longer, 'twill be eaſy then to know what muſt be taken from ſome or added unto others, to make them equal to them that are truly 24 Hours, which in ſhort is the true Buſineſs of the Equation of Time: And though this cannot be done in the Natural Day it ſelf, yet knowing how much all Days do differ from 24 Hours, the Motion of a Clock may yet be adjuſted thereby to a true Pendulum or 24 Hour Day, by making it either loſe or gain ſo much as the Days do exceed or fall ſhort of 24 Hours.

And this may well enough be performed by the Tables of Signs and Tangents, for by theſe you may readily frame a Table of the Sun's natural right Aſcenſions; and this ſhall ſhew you what Degrees of the Equinoctial are each Day upon

upon the true Meridian, when the Sun comes to it. Now these being in their measure of Degrees and Minutes sometimes more, and sometimes less, you must next find out what a mean or equal right Ascension will amount to by dividing the 360 Degrees of the Equinoctial into 365 Parts, agreeable to the number of Days contained in a Year; then compare each natural right Ascension with the mean ones, and by substracting the lesser from the greater, you will by turning the differences between them into Time, come to know their true Equation, that is, how much each Day is longer or shorter than 24 Hours; for so much as the natural right Ascension is more than the Mean in Time, so much is that Day longer than 24 Hours; and so much as the Natural is less than the Mean, so much is that Day wanting of 24 Hours long.

But Men may now well spare themselves the trouble of doing this, in regard that Tables of this nature are already published by divers excellent and learned Men: As first, by Mr. *Hugens*, Printed *Novem.* 29. Of the *Philosophical Transactions:*

actions: Secondly, by Mr. *Flamsteed*, commonly made use of by Mr. *Tompion*, Printed also in *Parker's Almanack*. Thirdly, by Mr. *Molyneux* in his *Sciothericum Telescopicum*, or ingenious Tract of the *Telescope Dial*. Fourthly, by the learned Dr. *William Salmon*, in his *Almanack* for this *Year* 1694. And fifthly, by Mr. *Samuel Watson*, the curious Contriver of that rare *Celestial Orbitery*, now in the present Queen *Mary*'s possession; in each of which the Equations are nearly enough the same for substance, as you will soon find by substracting any of their Numbers from the greater next it; and 'tis not material which you choose, provided you understand them rightly; but for my part I believe, from good Experience, there are not many that truly do this; and therefore having for some Reasons which I shall not now mention, made choice of Mr. *Hugens*'s Equations, for the Uses intended in this Work; I have thought fit to cast them into such peculiar Forms of my own, as I judge more plain and natural than they are in the Form in which I find them published in the *Philosophical Transactions*; and I

believe will, by the generality of them that are poſſeſt of *Royal Pendulums*, be better underſtood too.

Now in order to underſtand rightly the firſt Equation Table for length of Days; take notice, that the firſt *Colume* contains the Days common to every *Month*, the other 12 *Columes* belong to the *Months* whoſe Names are ſet over them; in the which, *D* 24. denotes which Days in the *Year* are juſt 24 Hours long; and where you find *red Figures*, there the Days are ſo many Seconds of Time above 24 Hours long, as the Figures expreſs; and where-ever the Figures are *black*, there the Days want ſo much of being 24 Hours, as thoſe Figures in Seconds of Time do amount to; ſo that by the Colour of the Figures, you may diſcern at what times the Clock will naturally gain or loſe, and by the ſum thereof, you will know the time ſo loſt or got each Day.

The *Table* being thus briefly explained, I ſhall now ſhew, how thereby to adjuſt a *Royal Pendulum* ſo exactly, as that its *Diurnal*, or Daily Revolutions, which is that of its twice 12 Hours going,

ing, may be equal to the true 24 Hour-Day: To do this, let the Clock be ſet right to the Sun, and note the Day on which 'tis ſo ſet; then let it continue going till you find the Time given by the *Sun*, and that which the Clock ſhews, viſibly to diſagree; obſerve then how much the difference is; that is, how much 'tis either too faſt, or too ſlow; then count how much the whole number of Seconds amounts to, included between the two Days of your firſt ſetting and laſt obſerving, ſave one, by allowing 60 Seconds to one Minute of Time, and if the difference between the Clock and the Sun be equal to what the ſum of Equations ſo caſt up amounts to, then is the *Pendulum* very well and truly ajuſted.

But in doing this, that is, in ſumming up the Equations contain'd in the *Table*, you muſt be ſure to obſerve, as I ſaid, to take in the Equation of the Day on which you ſet it, and leave out that which belongs to the Day of your laſt obſerving; for ſhould the laſt be taken in, they would make the ſum of Seconds loſt or got to be ſo much more than the truth,

and if it hath both got or loſt during the time it has gone, as it ſometimes may happen, when the Sun appears not of a long time, to make an Obſervation, then you muſt ſubſtract the leſſer ſum of Equations from the greater, and the Remainder ſhall ſhew the true time loſt or got; as if the gaining Numbers be 20, and the loſing 15, then the true time it ſhould have got, is juſt 5 Minutes.

But if the Clock have gone more too faſt or too ſlow, than the ſum of the Equations in the *Table* amounts to, then muſt the Motion of it be altered accordingly, by ſcrewing up the *Bob*, or making the *Pendulum* ſhorter, in caſe it has gone too ſlow, or by letting the *Bob* down longer, in caſe it has gone too faſt; and then having ſet it true to the Sun a ſecond time, try it again, as you were before directed, and if its diſagreement with the Sun be not yet anſwerable to the ſum of the Equations belonging to the time it has gone in, let the *Bob* be rectified a ſecond time, and let the Clock be ſet a new; and thus continue to do, till you find its difference with the Sun to be nearly equal to the

ſum

ſum of Equations contain'd in the *Table*.

Now when the Clock is by this means adjuſted right, its Daily Revolutions, or each 24 Hours time of its going will be equal to the true 24 Hour-day, or the juſt 365th part of a *Year*; for if a *Year* be exactly divided into 365 parts, each of theſe parts will be equal in length to the 24 Hours motion of a well adjuſted *Pendulum*, and the Motion of a *Pendulum* ſo exactly regulated, will be ſuch, that if it be at any time ſet right, and ſo let go the whole *Year* about, it will the ſame Day Twelve-month agree nearly with the Dial to which it was ſet a *Year* before.

But yet in its Courſe of thus going a whole *Year* round, 'twill ſometimes be found to differ very much from the ſame Dial 'twas at firſt ſet to; and theſe various Differences which its Motion will be ſubject to, will ſtill be agreeable to what the nature of the time was 'twas ſet in: For ſet at one time of the *Year*, t'will be always more or leſs too ſlow, till the time of its coming right the ſame Day Twelve month: Set at an-

other time 'twill go always too fast till just the same Day Twelve month: Set at some other time, 'twill go sometimes too fast, and sometimes too slow; the Reason of which is plain and evident by the *Table* of Equations that gives the length of natural Days.

For it appears by that, that in all that Space where *black Figures* are found, there the Clock will still go too slow, because the *Pendulum Day* is longer than the *Natural Day:* On the contrary, where the *red Figures* are found, there a well adjusted Clock will go always too fast, because there the *Pendulum Day* is shorter than the *Natural Day*, and by consequence is finish'd before it.

Now 'tis plain, that if a Clock be set right to the Sun the First of *February*, it must go all the *Year* after too slow, because the losing between that and the Fourth of *May*, is so much, that it never gains it up till the very last part of its *Years* going: On the contrary, if it be set right the Twenty third of *October*, it will gain so much by the last of *January*, as no Loss shall afterwards countervail; but that in the very last part of its *Years* going

going between the Sixteenth of *July*, and the Twenty first of *October*. 'Tis likewise as plain, that if a Clock be set right the Fourth of *May*, 'twill then in the time of a *Years* going, be both too fast, and too slow; for the gaining at first being less than the next losing, it will be too slow by the Twenty first of *October*, though 'twas too fast the Fifteenth of *July*; and the like will happen if it be set right the Seventeenth of *July*; for the losing that follows being less than the next gaining between *October* 24, and *January* 31. it must by consequence be sometimes too fast, and sometimes too slow.

So that as a Clock may happen to be set, it may in some considerable time of going, be almost half an Hour too fast, or half an Hour too slow, though as to its own Motion it go exact and true, as it should do; and for this there is no help, unless you understand well the nature of Time, and know when and in what manner to set the Clock, so as that for some good length of time after, he may so humour the Sun's motion, as never to be very far distant from

it; but ſometimes too faſt a little, and in a little time fall back again as it were, and ſo come to be right therewith, and then in a little time after be a little too ſlow.

Now therefore in order to the reducing of the Motion of a well adjuſted Clock much nearer the time given by the Sun, than as yet any known Rule will direct us; I have with great Care and Pains, Compoſed a Second *Table* of *Equations*, that ſhews how a good and well adjuſted *Pendulum* may be kept all the *Tear* round within a great deal leſs for the moſt part than $3^{l}\ 45^{ll}$ of the time given by the Sun, or the 4th part of a quarter of an Hour, which is ſo ſmall a matter as not to be perceived in common buſineſs: Now in the explanation of the *Second Table*, note;

That the *Firſt Colume* contains the *Days* of every *Month*, the other *Twelve Columes* belong to the *Twelve Months* of the *Tear*, whoſe *Names* are plac'd over them; the *Black Figures* in any part of the *Columes*, ſhew where and how much a Clock in the *Natural Courſe* of its *Motion*, according to the deſign of the *Table*,

ble, will loſe or go too ſlow; the *Red Figures* ſhew in what *parts* of the *Year*, and how much in *Minutes* and *Seconds* of *Time*, the Clock will go too faſt: As for the *Days* on which you find this *Character* ⊙, thoſe *Days* I call *Rectifying Days*, becauſe on them the Clock is ſtill to be new ſet, in order to keep it the better within the Limits deſign'd by the *Table*: The *Table* thus *explain'd*, I ſhall come now to ſhew you the *Uſes* that may be made thereof.

And firſt, I will ſhew you how by the *Table* alſo, as well as by the *firſt*, a Clock may be adjuſted now to do this. Let this Clock be ſet to the Sun on any Day, that is not a *Rectifying Day*; obſerving this always, to ſet it ſo much too faſt, as the *Red*, or too ſlow, as the *Black Figures* do expreſs, and then let it go for any conſiderable time, provided it be not beyond a *Rectifying Day*; and note whether its gain or loſs be at any time equal to what the *Table* allows; if it is, then the Clock is truly adjuſted; but if it have loſt, or got more or leſs than it ſhould do, then *rectifie* the *Bob*, by making it ſhorter, if it have gone too

ſlow,

ſlow, or ſcrewing it down longer, in caſe it has gone too faſt; then ſet it anew, and obſerve it a *ſecond time*, continuing your altering of the *Bob*, and new ſetting, till you have brought it to rights.

For example, Suppoſe you ſet it the Sixth of *January*, you muſt upon this Day ſet it too ſlow by one *Minute* fifty two *Seconds*, becauſe the time is there ſet down in *black Figures*; let it go till the 11th of *February*, on which Day if it be well adjuſted, it muſt be 2′ 9″ too faſt, becauſe that ſum of time is there ſet down in *red Figures*; but if it ſhould happen to be too ſlow, or too faſt for that time, as ſuppoſe 10 *Minutes* too faſt, inſtead of 2′ 9″, you muſt then adjuſt it nearer by ſcrewing the *Nut* of the *Bob* down lower, or making it longer, by what means ſoever the ſame is to be effected; then ſet it anew juſt ſo much too faſt as the *Table* for that *Day* does allow, and ſo let it go till the 4th or 5th of *March*, on which *Day* obſerve it again, and correct what you find to be amiſs in the *Motion*: Note hear, that in adjuſting by this *Table*, you ſave your ſelf the labour

bour of caſting up the ſum of thoſe *Equations* that belong to the time the Clock has gone in, and by conſequence the work of adjuſting will be eaſier done by this, than by the former *Table*.

When the Clock is well adjuſted, it may then be kept the whole *Year* about as near the true time, as the deſign of the *Table* allows of, by the following method; about 12 a Clock on any *Day*, which is not a *Rectifying Day*, ſet it ſo much too faſt or too ſlow for the Sun, as the *Equation* in the *Table* for that *Day* comes to, that is, too ſlow if the *Figures* are *black*, or too faſt if the *Figures* are *red*; then let it go on till a *Rectifying Day* comes, which is known in the *Table* by this *mark* ⊙, upon which *Day* about *Noon*, ſet it backward from the place where the *Hand* then ſtood, if the *Figures* on that *Day* are *black*, or forward if they be *red*, ſo much in time as the *Figures* expreſs, and obſerve to do the ſame upon every other *Rectifying Day*, and then if the Clock be well adjuſted, it will go in all the *intermediate parts*, according to the *time* given by the *Table*.

Take

Take one Example to make this plain, Suppoſe you have not an Opportunity to ſet it till the 18th of *January*, the Equation for that Day is one Minute 24 Seconds too faſt; becauſe the Figures are Red let it therefore be ſet ſo much too faſt for the Sun, and let it go till the 8th of *March*, on which Day, about 12 a Clock, ſet it forward from the Place the Hand is at 7′ 29″, becauſe the Figures are red, and then inſtead of being too ſlow, as it before was, it will be made to be 3′ 45″ too faſt; let it go till the 31ſt of that Month, and then ſet it again forward 7′ 16″; after which, on the 4th of *June*, ſet it back 5′ 8″, becauſe there you find Black Figures: On the 22d of *Auguſt* ſet it alſo forward 7′ 23″, and on the 12th of *September* 7′ 17″; ſet it forward likewiſe on the 8th of *October* 5′ 20″, and alſo on the 15th of *November* 7′ 20″; likewiſe on the 3d of *December* let it be ſet back 7′ 28″, and on the 18th 7′ 3″. and on the firſt Day of the next Year 7′ 8″: And thus, with a very little Pains and Trouble you may keep a Clock near the true Time of the Day by a more eaſy Way and

Method

Method than has at any Time been practiſed heretofore.

But in caſe you ſhould miſs rectifying your Clock on a rectifying Day, then you muſt the next, or any other Day following ſet him by the Sun ſo much too faſt or too ſlow, as the Nature of the Table requires; and then he will again go on in that Order which the Deſign of the Table makes neceſſary; that is, he will then be capable of humoring the Suns Motion ſo far as that (between being ſometimes a little too ſlow and othertimes a little too faſt) 'twill, with a little Rectification be always within leſs than a fourth Part of a quarter of an Hour of the true Time. In ſuch Clocks as ſhew not Minutes the Time of ſetting muſt be gueſt at as well as you can.

Now the Reaſon of thus ſetting a Clock ſometimes backward and ſometimes forwards, upon the rectifying Days, is this, If a Clock, at the beginning of the Year, be ſet to the Sun, according to the former Directions, it will be too ſlow by the 8th of *March* at Noon, 3′ 44″: Now the Deſign of the Table being

being to keep the Clock ſo as that it ſhall at no Time diſagree with the Sun above 3′ 45″, or the fourth part of a quarter of an Hour: I then (to prevent its being more too ſlow, as it will, if let go longer) am neceſſitated to ſet it forward 7′ 24″, and then 'twill be too faſt for the Sun 3′ 45″. Now the Clock naturally loſing, at this Time of the Year, it will again, by the 31ſt Day be too ſlow 3′ 31″: Now the Clock being ſtill naturally inclined to loſe, I therefore, to prevent his being above 3′ 45″ too ſlow, ſet him again 7′ 16″ forward from the Place where the Hand then ſtands, and ſo he is again too faſt for the Sun 3′ 45″ (which is the moſt that I ſuffer him to differ from the apparent Time) Now, after this, he going on, for about 9 Weeks, will the 4th of *June* be too faſt 1′ 23″, at which Time I ſet him back 5′ 8″, that ſo he may be now 3′ 45″ too ſlow, for by thus doing he will continue going the longer, before he will require to be again new ſet; which next happens to be *Auguſt* 22d, which is above 11 Weeks Time: Now the like Reaſon is the Cauſe of his requiring to

be

be ſet anew in any other Place or Part of the Year.

And here I think fit to add one Caution to thoſe that deſire to adjuſt their Clocks very nicely; and that is, that among Dials, they make uſe only of the horizontal or braſs Dials, which are fixt on Poſts, for no other can poſſibly give the Time ſo near the Truth; neither on that ſhould they make uſe of above one certain Hour; and the nearer Noon that is the better, for 'tis a difficult thing, even for the beſt Maſters in this Art, to draw a Dial ſo true as to contain an equal Time between all its Hours; which though in other Caſes it be not very material, yet in this of adjuſting a Clock it may cauſe a conſiderable Error: Beſides, few Dials are fitted truly to the Latitudes in which they ſtand; and if we could be certain that all were right, as to theſe Particulars, yet no Human Art can prevent the Sun's Refractions, which as they make his Body appear much bigger when near the Horizon, ſo they make him for a good part of the Day to ſhew to us higher than really he is, and that muſt cauſe him to give a falſe

falſe Shadow on the trueſt Dial; ſo that theſe particulars conſidered together, 'tis plain that there can be no true account taken of the Time till near Noon, or 12 a Clock; and he that watches for that Moment need not matter the falſneſs of the Dial, wrong Latitudes, nor Refractions neither, becauſe upon the Meridian let the Sun be higher or lower, yet it ſtill gives you the true 12 a Clock.

But in regard 'tis ſo very hard to diſtinguiſh to a Minute by the Shadow of the beſt Dial, ſmall ones not admitting of minute Diviſions, and in large ones the Hazineſs or Faintneſs of the Shadow renders a minute difficult to be diſcerned exactly; 'twill therefore be better if inſtead of a Dial you make uſe of the following Device, which I call a Meridian Cranny; Take then Two plain and flat Plates or Boards, about ſix or eight Inches ſquare, joyn them ſo cloſe as that an old Groat or a Six Pence at the moſt may but paſs between them, let them be then fixed ſo as that the Chink or Cranny between them may reſpect, as near as may be, the Meridian or true South Point, this will plainly give you the

Time

Time to half a Minute and leſs, if you are careful to watch, for the very firſt Beam, that by the Sun's coming to the South ſhall be darted through it, which may be perceived in a Moment by the help of a ſmooth Board or Plate of Braſs, made black, and placed near it, on the North Side, to receive the Light; by this means the true Time of the Sun's coming to the very ſame Point on the Meridian may be more exactly obtained than it can be by the beſt and trueſt *Dial*, except ſuch a one as is deſcribed by Mr. *Molyneux* in his *Sciothericum Teleſcopicum*.

But now, although the true Time of the Sun's coming to the South may, by this means be more nearly obtained, yet you will, for all that, find the Work of truly adjuſting a Clock to be exceeding difficult, eſpecially to do it preciſely, when you have already brought to go prety nearly tru, and this has made ſome to cenſure the Equation Tables, as falſe, becauſe they could never adjuſt a Clock ſo as to acord therewith exactly, or come Right the ſame *D*ay twelve Month with

that Dial, to which it was ſet a Year before.

Now, that I may do right to Truth, I affirm that this proceeds not from any material Defect in the Tables, but either from their not rightly underſtanding which way to perform the Work they took in hand, or from ſome other unavoidable Accidents, with which Nature too often ſports her ſelf in the Diſappointment of Men's Deſigns: 'Tis probable indeed that there may be ſome Error in the Tables, as ſuppoſe a Minute at the moſt, this ſignifies little as to the Buſineſs in hand, and if it did, yet we ought to value a Guide that will bring us in ſight of the thing we aim at, rather than follow an apparent Uncertainty, as I have proved thoſe do that would attempt to adjuſt a Clock by barely ſetting of it true to the Sun; there muſt be grains of Allowance given for Human Infirmity, for no Man, that underſtands himſelf, dares pretend to an infallible certainty in things ſo much above him as thoſe are about which Aſtronomy is converſant, there's no meaſuring the diviſions of the Celeſtial Spheres with Scale and Com-

Compaſſes, all our Knowledge in things of this nature is derived from Obſervations made by Inſtruments, which we know is ſo difficult to be done exactly, that if ten Men ſhould attempt at the ſame Time to find out the Sun's Declination (the Ground-work on which Equations are built) perhaps they would all differ, as to their Accounts thereof: Now, we know, if the Premiſes are never ſo little out, the Concluſions drawn therefrom can never be exactly and critically true.

Therefore, granting the Poſſibility of ſome inconſiderable Error in the Tables of Equation, yet ſtill we are ſure of this, That they come ſo near the Truth, that perhaps no Man can hereafter Mend 'em; and the Work of adjuſting a Clock is thereby made a hundred Times more eaſy than it would be to do it without them: Beſides, we ſee that the moſt learned in Aſtronomy agree all of them as to the mean thing, namely, That there is ſuch a thing as Difference in the length of Natural Days, and their Tables all agree as to the Parts of the Year in which theſe Differences happen;

they alſo accord very nearly ſo as to the Quantity of Time that any natural Day is longer or ſhorter than 24 Hours, and therefore we may very well reſt ſatisfied that there are no material Errors committed therein; and perhaps could we demonſtrate any Table of Equations to be really exact to a tittle, yet this Work of adjuſting a Clock truly would not be found more eaſy to do then than now it is, for much of this depends not only upon the right underſtanding which way to perform beſt the Work we are about, but on the Conſtant Temper of the Air, as will hereafter appear.

But, to the end that we may not be in the dark, as to the true Nature of this Difficulty, I affirm that it chiefly proceeds from the exceeding niceneſs of rectifying the Bob exactly, when you have already brought the Clock to go pretty near the true Time; as ſuppoſe, for example, that a Royal Pendulum were ſo well rectified, that being kept going the whole Year round, it ſhould be juſt at the ſame Day Twelve Month but 6′ 5″ too ſlow for the Sun, which ſome perhaps will account a great matter;

now

now this turn'd all into Seconds makes just 365, and by consequence the Clock has gone each Day but a Second of Time too slow.

Now, by the following Table of Pendulums, we find that a Royal Pendulum 41 Inches long, each Blow of which is a Second of Time, strikes just 3600 Blows in an Hour: Now this Pendulum will go faster by 45 Blows in an Hour, if screw'd up an Inch shorter, which is faster in a Day near 1080 Seconds; now if an Inch shorter makes a Pendulum go near 1080 Seconds in a Day faster 'twill then require the Bob to be screwed up but the thousand and eigtieth part of an Inch to make it go in a Day but one Second faster, or so much as the Clock is said to have lost; which is so very small a matter that no Man living can by guess hit it exactly, the least Turn that shall be given it may perhaps make it go ten Times as much too fast as it before went too slow.

Now to the end that this may, if possible, be done by some more certain Rule & Method than any yet commonly known, I will here make bold to propose a way

by which this may be performed more exactly than heretofore, and by which you may make a near Eſtimation how much a Royal Pendulum that ſtrikes Seconds (for this ſort only is here intended) ought to be made ſhorter or longer, to go faſter or ſlower a Second in a Day, and the ſame Rule by which you know how to alter it one Second will direct you how to alter it 2 or 3, or more if occaſion require it.

By the forementioned Table of Pendulums, we find that a 41 Inch Pendulum goes 45 Blows (which are all nearly Seconds) in an Hour faſter, if ſcrewed up an Inch higher; and being let down an inch longer; it then goes 43 Blows ſlower, that is, ſtrikes ſo many Blows leſs in an Hour; now if between theſe 2 Numbers we take a mean one, which is 44, 'twill be ſuitable to the Lengths near 41 Inches, for ſo many Blows will a Pendulum 39 and an half ſtrike more than one of 41 Inches and an half long: Now 44 difference in an Hour makes in a Day 1056. divide this number 1056 by the number of Turns which the Screw of your Pendulum makes in an Inch, and

and the Quotient ſhall be the Number, into which the Nut of that Screw muſt be divided; now one of theſe Diviſions turned about ſhall alter the Motion of that Pendulum a Second in a Day.

But to avoid the Trouble of thus dividing, I have here added a Table, by which, knowing the Turns your Screw makes in an Inch, you may, by Inſpection only know how to divide the Nut that belongs thereunto, the Table reaches from 15 Threds or Turns of the Screw in an Inch to 40, within which Numbers, I ſuppoſe, all Screws will be comprehended, that belong to Pendulums that ſtrike Seconds.

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that Dial, to which it was ſet a Year before.

Now, that I may do right to Truth, I affirm that this proceeds not from any material Defect in the Tables, but either from their not rightly underſtanding which way to perform the Work they took in hand, or from ſome other unavoidable Accidents, with which Nature too often ſportsher ſelf in the Diſappointment of Men's Deſigns: 'Tis probable indeed that there may be ſome Error in the Tables, as ſuppoſe a Minute at the moſt, this ſignifies little as to the Buſineſs in hand, and if it did, yet we ought to value a Guide that will bring us in ſight of the thing we aim at, rather than follow an apparent Uncertainty, as I have proved thoſe do that would attempt to adjuſt a Clock by barely ſetting of it true to the Sun; there muſt be grains of Allowance given for Human Infirmity, for no Man, that underſtands himſelf, dares pretend to an infallible certainty in things ſo much above him as thoſe are about which Aſtronomy is converſant, there's no meaſuring the diviſions of the Celeſtial Spheres with Scale and Com-

Compaſſes, all our Knowledge in things of this nature is derived from Obſervations made by Inſtruments, which we know is ſo difficult to be done exactly, that if ten Men ſhould attempt at the ſame Time to find out the Sun's Declination (the Ground-work on which Equations are built) perhaps they would all differ, as to their Accounts thereof: Now, we know, if the Premiſes are never ſo little out, the Concluſions drawn therefrom can never be exactly and critically true.

Therefore, granting the Poſſibility of ſome inconſiderable Error in the Tables of Equation, yet ſtill we are ſure of this, That they come ſo near the Truth, that perhaps no Man can hereafter Mend 'em; and the Work of adjuſting a Clock is thereby made a hundred Times more eaſy than it would be to do it without them: Beſides, we ſee that the moſt learned in Aſtronomy agree all of them as to the mean thing, namely, That there is ſuch a thing as Difference in the length of Natural Days, and their Tables all agree as to the Parts of the Year in which theſe Differences happen;

they alſo accord very nearly ſo as to the Quantity of Time that any natural Day is longer or ſhorter than 24 Hours, and therefore we may very well reſt ſatisfied that there are no material Errors committed therein; and perhaps could we demonſtrate any Table of Equations to be really exact to a tittle, yet this Work of adjuſting a Clock truly would not be found more eaſy to do then than now it is, for much of this depends not only upon the right underſtanding which way to perform beſt the Work we are about, but on the Conſtant Temper of the Air, as will hereafter appear.

But, to the end that we may not be in the dark, as to the true Nature of this Difficulty, I affirm that it chiefly proceeds from the exceeding niceneſs of rectifying the Bob exactly, when you have already brought the Clock to go pretty near the true Time; as ſuppoſe, for example, that a Royal Pendulum were ſo well rectified, that being kept going the whole Year round, it ſhould be juſt at the ſame Day Twelve Month but 6′ 5″ too ſlow for the Sun, which ſome perhaps will account a great matter;

now

now this turn'd all into Seconds makes juſt 365, and by conſequence the Clock has gone each Day but a Second of Time too ſlow.

Now, by the following Table of Pendulums, we find that a Royal Pendulum 41 Inches long, each Blow of which is a Second of Time, ſtrikes juſt 3600 Blows in an Hour: Now this Pendulum will go faſter by 45 Blows in an Hour, if ſcrew'd up an Inch ſhorter, which is faſter in a Day near 1080 Seconds; now if an Inch ſhorter makes a Pendulum go near 1080 Seconds in a Day faſter 'twill then require the Bob to be ſcrewed up but the thouſand and eigtieth part of an Inch to make it go in a Day but one Second faſter, or ſo much as the Clock is ſaid to have loſt; which is ſo very ſmall a matter that no Man living can by gueſs hit it exactly, the leaſt Turn that ſhall be given it may perhaps make it go ten Times as much too faſt as it before went too ſlow.

Now to the end that this may, if poſſible, be done by ſome more certain Rule & Method than any yet commonly known, I will here make bold to propoſe a way

by which this may be performed more exactly than heretofore, and by which you may make a near Eſtimation how much a Royal Pendulum that ſtrikes Seconds (for this ſort only is here intended) ought to be made ſhorter or longer, to go faſter or ſlower a Second in a Day, and the ſame Rule by which you know how to alter it one Second will direct you how to alter it 2 or 3, or more if occaſion require it.

By the forementioned Table of Pendulums, we find that a 41 Inch Pendulum goes 45 Blows (which are all nearly Seconds) in an Hour faſter, if ſcrewed up an Inch higher; and being let down an inch longer; it then goes 43 Blows ſlower, that is, ſtrikes ſo many Blows leſs in an Hour; now if between theſe 2 Numbers we take a mean one, which is 44, 'twill be ſuitable to the Lengths near 41 Inches, for ſo many Blows will a Pendulum 39 and an half ſtrike more than one of 41 Inches and an half long: Now 44 difference in an Hour makes in a Day 1056. divide this number 1056 by the number of Turns which the Screw of your Pendulum makes in an Inch, and

and the Quotient ſhall be the Number, into which the Nut of that Screw muſt be divided; now one of theſe Diviſions turned about ſhall alter the Motion of that Pendulum a Second in a Day.

But to avoid the Trouble of thus dividing, I have here added a Table, by which, knowing the Turns your Screw makes in an Inch, you may, by Inſpection only know how to divide the Nut that belongs thereunto, the Table reaches from 15 Threds or Turns of the Screw in an Inch to 40, within which Numbers, I ſuppoſe, all Screws will be comprehended, that belong to Pendulums that ſtrike Seconds.

The Table for dividing the Nut of a Pendulum Screw.

Turns	Divisions
15	70
16	66
17	62
18	58
19	55
20	52
21	50
22	48
23	45
24	44
25	42
26	40
27	39
28	37
29	36
30	35
31	34
32	33
33	32
34	31
35	30
36	29
37	28
38	27
39	26
40	25

The Uſes of the Table for dividing the Nut of a Pendulum Screw.

Find out how many Threds or Turns of your Screw are contained in an Inch, by applying the Inch-Diviſion of a Rule thereunto, which number of Turns ſeek out among the firſt Row of Figures on the Left Hand, and againſt it, in the ſecond Row, you have the Number that the Nut muſt be divided into that belongs to that Screw: Now the Nut, turn'd about but one of theſe Diviſions, will alter the Clocks Motion a Second in a Day; ſo that let the Screw be finer or courſer, yet by this Table you may readily know into how many Diviſions its Nut muſt be divided. Note, that if the Clock has got or loſt in a Day above one Second, then you muſt turn the Nut about ſo many Diviſions; as if it have loſt in 60 Days 4 Minutes, which is 4 Seconds in a Day, turn it then upwards 4 Diviſions, and that will make it go 4 Seconds in a Day faſter, or ſo much Time as it had gone too ſlow: And the like muſt be done for any other Number loſt or got.

Now

Now though this Rule be ten times more exact than any yet known, yet for all that it may be yet found difficult to make a Clock go exact, especially for a long time together; for though a *Royal Pendulum* be the most excellent Contrivance in the World for exactness of keeping *Time*, yet the different degrees of *Rarity* and *Density* in the *Air*, does oftentimes alter the nature of the *Pendulums motion*, a *thick Air* not suffering it to *vibrate* so freely, nor so far as a *thin Air* does; the *Motion* of the *Pendulum* may be also somewhat altered by the *Oyl* growing drier and thicker with which the *Penets* are moistned; for when a Clock is clean, and the *Oyl* thin and free from foulness, the *Pendulum* plays differently from what it does when the Clock is foul, and the *Peuets* dry and dirty: But here you are to note, That notwithstanding the *Royal Pendulum* is subject to be altered somewhat in its *Motion* by the aforesaid Causes, that 'tis nothing in comparison to what happens in the common Crown-wheel *Pendulum*, for these are apt to be varied ten times more than the other, which still makes

makes very much for the Reputation of the *Royal Pendulum*.

Since then the *Air*, and *Oyl*, and *Duſt*, are apt to cauſe the beſt Clock to go leſs certain, than it otherwiſe would; I have thought fit to propoſe a way by which it may be known when any thing conſiderable of this nature happens, and that is thus, Screw or faſten to the back of the Caſe a *braſs Plate*, with 2 ſliding *Indexes* fitted to it, that may be ſet exactly to the Compaſs which your *Pendulum* fetches, and by that you may perceive whether your Pendulum alters in its Compaſs, for ſhould it do ſo in the time of your adjuſting of it, you will find it a very hard matter to *rectifie* it well; and if nothing of this happens till it be brought to go compleatly true, yet if the Compaſs of your Pendulum does afterwards differ, you will certainly find it not to keep the ſame time it did when firſt adjuſted, and the beſt Clocks that are will ſometimes be ſubject to theſe unavoidable Accidents.

But although thoſe little Irregularities in the Motion of a good Pendulum, may ſometimes happen and prove ſome hindrance

drance to the exactneſs of its Motion, yet when you come to know how much it varies from the truth, you may ſoon correct it by the foregoing Rules, if you ſee occaſion. Indeed a conſtant Inclination to go either too faſt, or too ſlow, argues rather a not being well adjuſted at firſt, for if it vary from the *Influence* of the *Air*, that aptneſs to go falſe will continue no longer when the temper of the *Air* returns to its former ſtate, and then the Clock will return to its old pitch of *Motion*; but if it happen through *foulneſs* (which may be gueſt at by its having gone true a long time before) then 'twill continue to go *Irregular* till the Clock be made clean, new oyl'd, and put in order: But when all is ſaid that can be ſaid on this matter, if the Clock be a well made Piece of Work, all theſe Alterations in the *Motions* will be ſo inconſiderable, as not to be worth the noting, if you obſerve conſtantly to ſet it according to the Deſign of the *Second Table*, and Correct it once or twice a *Year* by the *Sun*: but for *baſe* and *ill Work*, no Art of Man can make that go exactly and well one Quarter of the time that the other will.

From

From all that has been ſpoken hitherto concerning the *Royal Pendulum*, we may gather that the ſame Exactneſs of keeping Time, is not to be expected in ſhort *Crown-wheel Pendulums*; Indeed if ſuch are *good Work*, they may be made to go very well, but yet not ſo exactly as the *Royal Pendulum*; for the ſhorter the Pendulum is, the more difficult it is to adjuſt it exactly: And when the adjuſting part is done never ſo true, yet the uncertainty that this kind of Pendulum is ſubject to in the Compaſs it fetches, will not ſuffer it to keep ſo equal a Time, as the *Royal Pendulum*; the different *Temper* of the *Weather* will alter it very conſiderably, if compared with the other; and 'twill alſo be ſooner out of order in the going, from the *foulneſs* and *thickneſs* of the *Oyl* that the *Pennets* are moiſtned with.

The beſt and eaſieſt way to adjuſt ſuch a Clock as this, is by a *Royal Pendulum* already *Rectified*, for a *Standard* to *Adjuſt* other Clocks by; for when by that you have brought a ſhort *Crown-wheel Pendulum*, (of which ſort all Spring-Clocks are for the moſt part) pretty

pretty near to the *Truth*, take exact notice how much it differs from it in either one Day or two Days, as you pleaſe; then give the *Bob* juſt a whole turn about upward, if it go too ſlow, or downward if it go too faſt; and ſee how much that *Turn* will make it differ from the *Standard* above what it did before in a Day, or two Days time. Now knowing how many *Seconds* in a *Day* a *Turn* of the *Bob* will alter, you may ſoon bring it to keep *true time*, by turning it ſo many *Turns* or *parts* of a *Turn about*, as ſhall anſwer the *Time* it has gone too faſt, or too ſlow.

As for thoſe *Pocket-Watches* which are now ſo *improperly* called *Pendulums*, there is leſs to be expected from *them* than from a *Crown-wheel Pendulum*; for though this *delicate Invention* of the *Ingenious* Mr. *Robert Hook* does ſtrangely *Rectifie* the *Motion* of the *Balance*, yet muſt it not compare with either of the other, as to the Truth of *going*, for 'tis the hardeſt *thing* in the World to make a *Watch* keep the ſame *Time*, when laid on what *part* or *ſide* ſoever, you will be pleas'd to turn it, which rightly conſi-

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dered, may reaſonably obtain for them ſome grains of allowance: All that I ſhall add more, is, that if you know but nearly how much the *turning* of each *Diviſion* on the *Juſtning Plate* will make it go either faſter or ſlower, you may then at any time with greater certainty, adjuſt it to a *Standard Pendulum*; and this any one may attain to with but the trouble of a little Obſervation; for if the Watch, for example, have gone too ſlow two Minutes in a Day, turn the *Juſtning Plate* about one Diviſion faſter, and if that Diviſion make it go four Minutes too faſt, in ſtead of the two, which before it went too ſlow, then conclude that that Diviſion has altered it in a Day ſix Minutes; and by conſequence if you turn it *two thirds* back, it will make the Watch go right as it ought to do.

I ſhall only add one more *Note* concerning *Spring Clocks*, or thoſe that go with *Crown-wheel Pendulums*; and that is, that although as yet they have not been capable of keeping ſo exact a Time as the *Royal Pendulum*, yet if the Pendulum of a Spring-Clock inſtead of playing upon

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I ſhall only add one more *Note* concerning *Spring Clocks*, or thoſe that go with *Crown-wheel Pendulums*; and that is, that although as yet they have not been capable of keeping ſo exact a Time as the *Royal Pendulum*, yet if the Pendulum of a Spring-Clock inſtead of playing upon

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an edge, as they now generally do, were hung upon a String, about two Inches long, and that Spring were ſo filled according to the Rules of Art, as that in the Pendulums vibration, it might bend proportionable to the *Cycloid*, its Center of Motion would then ſtill ſhorten, as the way of its *vibration* grows longer; and by conſequence the farther the Pendulum ſwings out, the quicker would its return be, and ſo all its *vibrations* whether longer or ſhorter, would be performed in the ſame equal time, and then its Motion would be much more ſteady than it is, and be nearly as exact as that of a *Royal Pendulum*.

The manner of Rightly fixing, or Setting up Pendulums *to go well.*

THE Difficulty of ſetting up *Pendulum Clocks* rightly in ſuch places where the help of the *Clock maker* cannot be had, is the Reaſon that many Gentlemen who live far off from *London*, are as yet unfurniſhed with them; and it alſo too often happens, that *Clocks* who at firſt have been ſet up well as to matter of going, have by accident been miſplac'd or jumbl'd awry, and ſo are made to ſtand ſtill and become uſeleſs meerly for want of Skill in the Owner to put them again to rights; in order therefore to Enable all Perſons not only to Set a Pendulum Clock up Rightly, but alſo to Reduce him again to rights, when by accident he is miſplac'd, I have here made publick the following *Directions.*

First, Let the Workman, by whoſe Hands the Clock is made, ſet him upright at home in his own Houſe, and there having made a through tryal of his going, let him then ſtop the Pendulum, and when 'tis perfectly at reſt, let him fix or drive into the back of the Caſe a ſtrong Stud of Braſs or Iron, with the end turn'd a little up, which he muſt place ſo as that the Beak that turns up may ſtand exactly under the lower end of the Pendulum Rod; and this will ſufficiently direct you how to Set him up in any other Place: For when the Clock is to be Set up by him that buys him; 'tis but placing the Caſe ſo that the end of the Pendulum Rod may hang juſt over the Beak of the Stud, and then he will ſtand upright as he did before in then Workman's Hands.

But in caſe this proviſion be not made, then the Rule to do it by, is this; Set the Clock up in the place 'tis to ſtand in, let the Pendulum and the Pulleys which uſually are fix'd to the Caſe be unfaſtned,

ned, hang on the Weights, and ſet the Pendulum a going, by making of it ſwing between the Sides of the Caſe; now if when the Clock is thus ſet a going, you find the Pendulum to beat equally, that is, if there be the ſame Diſtance of Time between all its Blows, which an attentive Ear will ſoon diſcover; then does the Clock ſtand well, and you muſt make him faſt to the Place he ſtands againſt: But if you find one Blow Beat in leſs Time than the other, then you muſt a little incline the Caſe to that Side which the Pendulum plays to, when he ſtrikes the ſhorteſt Blow, and then you will find him to Beat more equal; and when you have inclin'd the Caſe ſo much, that you find exactly the ſame Diſtance of Time between the Blows or Vibrations; then the Clock ſtands right for Going, and you are to fix Him that He may ſtand firmly in that Poſture.

Now the Rule before given, is general to all Pendulums; for they all muſt

ſtand ſo that the Beats of the Pendulum may be equally diſtant as to length of Time, for otherwiſe if they ſtand awry, ſo that one Blow, or Vibration of the Pendulum is ſtruck in leſs time than the other, that Pendulum upon the leaſt accident that ſhall happen, will be apt to ſtand ſtill; and therefore great Care ought to be taken, that not only *Royal Pendulums*, but alſo *Spring Clocks* be ſet up exactly upright in the Places that they are, to ſtand in, and they never ſtand upright as they ſhould do, unleſs the Blows of the Pendulum beat equally.

Note, That as a long Swing-Clock ought to ſtand ſo as that the Pendulum beat equally, ſo he muſt ſtand ſo as that the Pendulum play free from the back of the Caſe, for if it ſtand right, in this reſpect the Rod of the Pendulum will all the way up, be parallel or equidiſtant from the back-part.

Moreover, take Care that the Clock be fix'd faſt and firm, that no Violence may juſtle Him out of his Place; but if by Accident it ſhould ſo come to paſs, you muſt then ſet Him again to Rights by the Rule before given from the exact beating of the Pendulum.

A Table of Crown-Wheel'd Pendulums, ſhewing the number of Beats made in an Hour, by any length of Inches and Quarters, from One Inch to Twelve, the Bob about an Ounce in Weight.

Inches	Beats
1 —	22946
1	20524
2	18735
3	17345
2 —	16225
1	15298
2	18735
3	13837
3 —	13248
1	12732
2	12265
3	11852
4 —	11473
1	11131
2	10817
3	10528
5 —	10262
1	10014
2	9781
3	9569
6 —	9368
1	9178
2	9000
3	8832

Inches	Beats
7 —	8672
1	8524
2	8381
3	8242
8 —	8107
1	7989
2	7870
3	7764
9 —	7653
1	7544
2	7448
3	7349
10 —	7256
1	7167
2	7081
3	6998
11 —	6919
1	6842
2	6767
3	6694
12 —	6623
1	6565
2	6497
3	6431

The

The firſt Row of Figures are Inches, the ſecond are Quarters of Inches; the Figures againſt each of theſe are the Beats that a Pendulum of that length make in an Hour: For example, 2 Inches beats 16225 Blows in an Hour; and 3 Inches and a half beats 12265; and 6 Inches 3 quarters beats 8832: Divide any of theſe Numbers by 60, and it ſhews you the Beats made in a Minute, multiply any of theſe by 24, and it ſhews you the Beats made in a Day.

A Table of Royal Pendulums, shewing what Beats any Length makes in an Hour from 12 to 60 Inches, the Bob 2 Pound Weight or more.

Inches	Beats	Inch.	Beats
12	6651	39	3691
13	6393	40	3645
14	6161	41	3600
15	5955	42	3557
16	5765	43	3515
17	5591	44	3475
18	5433	45	3436
19	5288	46	3399
20	5154	47	3362
21	5030	48	3327
22	4915	49	3293
23	4807	50	3260
24	4706	51	3228
25	4610	52	3196
26	4522	53	3166
27	4437	54	3137
28	4356	55	3108
29	4281	56	3080
30	4209	57	3053
31	4141	58	3027
32	4075	59	3001
33	4013	60	2976
34	3953	61	2951
35	3897	62	2927
36	3843	63	2904
37	3790	64	2880
38	3793	65	2859

In this Table, the firſt Row of Figures, in each Columne, are the Inches of a Pendulum's Length: The ſecond Row are the Beats that a Pendulum of that Length makes in an Hour. Thus one of 41 Inches long beats 3600 times, and one of 64 2880.

The

The Table of Royal Pendulums continued, from 3 Foot long to 30, for the Use of such as make Church and Turret-Clocks.

Feet	Beats
3	3842
4	3327
5	2976
6	2716
7	2515
8	2353
9	2218
10	2104
11	2006
12	1912
13	1845
14	1778
15	1718
16	1664
17	1614
18	1568
19	1526
20	1488
21	1452
22	1429
23	1387
24	1353
25	1331
26	1305
27	1288
28	1257
29	1235
30	1215

In

In this Table, the first Row of Figures are the Feet of any Pendulum's Length, the second Row are the Beats that that Length makes in an Hour; as 10 Foot long beats 2104 in an Hour, so a Pendulum of 20 Foot long beats 1488 Blows in an Hour.

The foregoing Table of Pendulums I was, in some measure necessitated to publish, in order to demonstrate why heretofore it has been found so difficult to adjust a Clock to the Table of Equations. But, besides this, I thought it might be of good Use to some, who, in contriving Numbers for new Clocks, or for old Clocks altered into Pendulums, are often at a loss what Length of Pendulum to fit their Number to. Perhaps my so doing may anger some, but the pleasuring of more will countervail that Mischief.

The Table of Crown-Wheel'd Pendulums is calculated from a Standard of the same sort, 6 Inches and a half long, that strikes 9000 Blows in an Hour: And that of Royal Pendulums from one of

41 Inches, that ſtrikes Seconds, or 3600 Blows in an Hour. In both the Tables you may perceive, That a Pendulum that ſtrikes but half ſo many Blows as another is four Times as long: This noted, gives you a true inſight into the Nature of the Pendulum. The Tables are exact, as to their whole Numbers, and would always give you the exact length, did not different ways of making Clocks cauſe an Alteration, inſomuch that ſometimes a Pendulum that ſtrikes Seconds ſhall be above a quarter of an Inch longer than another ſhall; we muſt bear with what we cannot avoid.

The beſt Rules for the

ORDERING and USE

Both of the

Quick-ſilver and Spirit

WEATHER-GLASS.

SInce 'tis ſo eaſy to be furniſhed in *London* with both theſe Sorts of Weather-Glaſſes, I judge it needleſs, now, to give any Directions about their Making; only thus much I ſhall take notice of, That the Goodneſs of a Baroſcope or Quick-ſilver Weather-glaſs does conſiſt wholly in the Largeneſs and Depth of the Ceſtern below, and the Quantity of Quick-ſilver contained therein. Now, that you may know whether a Ceſtern be large enough, cauſe the Work-

Workman, that makes it, to fill the Tube about 3 Inches, with part of the *Mercury* deſigned for its uſe; fill the Ceſtern with the beſt part of the reſt that remains; and then clapping acroſs the Brims at the Ceſtern, a Gage, that ſhall have a Pin drove into it, reaching juſt down to the Surface of the *Mercury*, let the *Mercury*, which before filled the 3 Inches of the Tube be put therein; and if you find it not to raiſe the *Mercury* in the Ceſtern above the thickneſs of a Six Pence, then is the Ceſtern of a ſufficient Capacity.

A Ceſtern of about 2 Inches and a half Diameter, generally, is large enough for any Tube, that has not a Bore above a quarter of an Inch Diameter, which is as large as is needful; for if it be ſo large, as that when the Quick-ſilver in the Glaſs, by riſing and falling, do raiſe that in the Ceſtern too conſiderably, then you will not conſtantly have that Diſtance between the Surface of the ſtagnant *Mercury* below and the numbred Figures on the Regiſter Plates of the Weather-Glaſs; for if the Glaſs be a good Glaſs, meaſure that Diſtance when you

you will, and you will always find it juſt 28, 30 or 31 Inches from the Diviſions ſo numbred to the Superficies of the Quick-ſilver, in the Ceſtern below.

Note likewiſe, That the End of the Tube ought to be emerſt at leaſt three quarters of an Inch within the Ceſtern of Quick-ſilver, elſe the Air will be in danger of getting up into the Body of the Tube: For this reaſon there ought to be at leaſt 28 Inches and 2 quarters Diſtance between the Figure 28, on the Regiſter Plate and the Bottom of the Ceſtern.

Now, in order to ſet the Weather-glaſs up, let the Frame be firſt fixed faſt to the Place you deſign for it; which is done by firſt driving therein a Nail or Tenter-hook, fitted, for that purpoſe, upon which the Frame is to be hung or ſuſpended, and, with a Screw, let the Bottom thereof be firmly faſtned to the Place, or, in want of a Screw, by ſomewhat elſe that may perform the Work well.

Then make the in-ſide of the Glaſs Tube very clean and dry, by means of a bright and clean piece of Wire, made red

red hot at the End in a Fire, and turned down for about half an Inch, like the Eye of a Needle, through which draw a long ſlip of fine ſoft Lawn Paper, which I find beſt for this purpoſe, becauſe 'tis not apt to leave any Lint behind it, as Linen Rags will; which Lint will always cauſe a ſmall Bleb of Air to remain round it, ſo that in ſpite of all your Care and Pains you ſhall never obtain a perfect fine Cilender of *Mercury*.

With this Paper, in the Eye of the Wire, let the Bore of the Tube be well cleanſed, by drawing of it to and fro, from one End to the other, till you are ſure that you have not miſt any Part thereof: And if you find, when you have drawn it out, that the Paper be any whit ſoiled, put in a freſh Piece, and after that another, till you find the Paper come out as clean at it went in, for ſhould any Foulneſs or Moiſture be left behind the *Mercury* will not play freely up and down.

When you have cleanſed the Tuble very well, then prepare and make the *Mercury* fit to fill it with, which you are to do in the manner following.

Take

Take an earthen Baſon or Diſh, and put therein half a Sheet of clean white Paper; then put the whole Quantity of *Mercury* which the maker of the Baroſcope has fitted thereunto, and having put it into a clean linen Cloath, ſtrain out gently ſo much of it as you judge will fill the Bore of the Tube and no more, for ſhould you twiſt and wring the Cloath, the Quick ſilver is in, to ſtrain it all through, you will, in ſo doing, find much Lint fall off from it, and foul the Surface of the *Mercury* ſtrain'd out, ſo that you cannot fill the Tube with it without conveying ſome of the Lint along with it, which will ſpoil the perfect ſmoothneſs of the Mercurial Cylender within the Glaſs.

When you have purely ſtrained out about one half of the Quick-ſilver, take the Tube, and reſting the cloſed end in ſome large wooden or earthen Veſſel, to ſave the *Mercury*, ſhould any ſpill in the filling; then graſpe the open end of it between the Root of the Thumb and Fore-finger, ſomewhat low, that the hollowneſs between may ſerve inſtead of a Tunnel; then fill the Tube with

the pure clean-ſtrain'd Quick-ſilver, by by taking of it up with the clean Bowle-end of a Tobacco-Pipe, or by putting of it into the Ceſtern-Glaſs, firſt wiped clean, and ſo pouring of it in till it be full, within a quarter of an Inch of the Top of the Tube.

Then, to cleanſe it from Air and Wind-Blebs, ſtop the End with your Finger, and raiſing the other End up, ſomewhat above a Level, let the Air, included in the empty Space, at the open End, riſe up very gently towards the Top or ſealed End, and this will take into it ſelf all the other Blebs of Wind that lye in its Way; and when this Bubble of Air is riſen up quite to the End of the Tube, let it return again, by depreſſing a little that End which before was uppermoſt, turning the Tube alſo, at the ſame time, that the Buble may take in its way all the Blebs of Wind that may yet remain on the other Sides of the Glaſs; and, thus, by turning the Tube a little, and making the Bubble paſs and re paſs from one End to the other, the Cylender of Quick-ſilver, will be at laſt cleanſed from all thoſe little Blebs of Wind that

that appeared by the Sides of the Glaſs, any of which, ſhould they remain in, would in Time work themſelves up into the Head of the Tube, and be very injurious to the Quick-ſilvers true Motion.

But if, as I noted before, the leaſt Moiſture or Lint be left in the Tube, the greateſt Care and Skill that can be uſed will not be able ſo perfectly to cleanſe it from Air, as not to leave the leaſt Speck remaining: In which Caſe there is no Remedy but to empty the Tube and cleanſe it anew, according to the Method before preſcribed. *Note*, when the Tube is perfectly cleanſed from Air, then turn the open End up, and fill it quite full with Quick-ſilver.

Then Wipe the Ceſtern very clean, and ſet it in its Place, in the Ceſtern-Box, then put therein all the remaining part of your *Mercury*, which you need not take care to ſtrain, for Duſt or Foulneſs in the Ceſtern ſignifies little; then take the Glaſs Tube, filled as before was taught, and ſtopping the End of it with your Finger, invert it ſo that you may immerge or put the End, ſtopt with

your Finger, the more eaſily into the Ceſtern *Mercury*, which ought to be done ſo that both Glaſs and Finger may touch the Ceſtern Bottom at the ſame time, keeping the Tube in the mean while as near an upright as you can, then of a ſuddain take away the Finger you ſtopt it with, and as ſuddainly, at the very ſame inſtant of Time raiſe the Tube juſt upright, the which, if you perform nimbly and well, will be done before the *Mercury* in the Tube is all ſunk down to its loweſt ſtation, and ſo the Tube will be put up well, without any admittance of outward Air.

But in caſe any Air ſhould get into the Tube, in your attempting to ſet it up in its Place, as ſometimes happens, then you muſt take it down again, by getting your Finger under the open End, to ſtop it, before you lift it out of the Ceſtern *Mercury*, and ſo repurge it of the Air got in, according as you were taught in the foregoing Method, and then try again to ſet it up well; and if you ſhould miſs this ſecond time, then try a third, for Experience will at length make you perfect.

When

When the Tube is put up obſerve whether it ſtand well in the Ceſtern, for ſome Ceſterns are ſo ill plac'd that the Tube, by reaſon of its being ſet too near the Side, cannot be well ſurrounded by the Ceſtern *Mercury*, by which means the Air will be apt to inſinuate it ſelf, and get up into the Tube, and ſpoil the *Mercury*'s true Motion.

If the Glaſs be already adjuſted to your Hand by the Workman that made it, you have then no more to do but to put into the Ceſtern all the *Mercury* that remains when the Tube is filled; but in caſe the Glaſs be not already adjuſted, or that ſome part of the Quick-ſilver ſhould be ſpilled or loſt, you muſt then provide to adjuſt it, according as the Rules of Art require: Which is done thus, Take a ſmall ſtreight Rod of Wood, of the juſt length of 28 Inches, this is generally called, *An adjuſting Gage*, put one End of it into the Ceſtern, and raiſe the other up till it touch the Diviſion on the Regiſter-Plate numbred with the Figure 28; then obſerve whether the Quick-ſilver in the Ceſtern does touch the other End, if it does

not, you muſt put in more *Mercury*, till it does; but if the *Mercury* be already above the lower End of the Gage, then you muſt, with the clean Bowle-end of a Tobacco-Pipe take out ſo much of the Quick-ſilver as that that in the Ceſtern may but juſt touch the End of the Gage, and then is the Glaſs compleatly and well adjuſted.

In caſe you have occaſion to remove a Baroſcope, or Quick ſilver Weather-Glaſs, out of one Room into another, you need only looſen the Frame and take it from the Place to which it is fixt, and ſo, upright, in the ſame Poſture it ſtood in, let it be carefully conveyed by Hand, ſo gently, and with a careful Step, that the Quick ſilver may not ſurge over the Sides of the Ceſtern, another Man, in the mean Time, making all things fit to ſet it up in its new Place, according to the Directions before given for ſetting of a Weather-glaſs up.

But here note, That if the Baroſcope be to be removed from one Houſe to another, it muſt be quite taken down: In doing which obſerve, Frſt, To incline the Tube ſo low as it ſtands in the Ceſtern,

ſtern, that the Quick-ſilver may riſe up quite to the top, then lift it out of the Ceſtern and let the *Mercury* run out, for ſhould you lift the Tube out in the Poſture it ſtands in, when going, the *Mercury*, by the Force of the Air's Preſſing in at the open End, would fly up to the top with ſuch Violence as to endanger the breaking off of the top of the Glaſs.

Note, That if the Glaſs Tube be not well purged of Air, the Quick-ſilver will, by long ſtanding, be apt to move contrary to the true Nature of a Baroſcope, by reaſon that the Air which has been left in the Tube, has by degrees got up into the Head or empty Space of it, where being expanded by any accidental Heat of Air, it occaſions the *Mercury* to ſink, though the Weight and Preſſure of the Air be no ways altered; this is obſerved by Dr. *Beale*, *Phyl. Tranſ.* numb. 9. p. 157. That a Baroſcope aſcended higher in the cold Mornings and Evenings than at Mid-day; which doubtleſs proceeded from the aforeſaid Cauſe; for if you leave, for tryal-ſake, a little Bubble of Air in the

Head of the Glaſs when you ſet it up, you will find the ſame Defect, as Dr. *Beale* has obſerv'd.

Wherefore 'tis neceſſary if you are doubtful of the like, to Rectifie your Weather-Glaſs, when it has been ſet up about a Twelve Month; which is done by taking of the Tube down, and repurging of it of Air, as you were taught in firſt ſetting of it up: but that you may not be put to more trouble than needs, you ought to be firſt certain that your Weather-Glaſs does want Rectifying, which you may know thus; Let the Tube as it ſtands in the Ceſtern be ſtoop'd down ſo low, till the Mercury riſe quite up to the Head, and if you perceive a Bubble of Wind at the top above the Quickſilver, that is the certain ſign of its wanting to be new Rectified; clap then your Finger under the open end in the Ceſtern, and take it out and purge out the Air, as before was directed, at its firſt ſetting up.

Of the Uſes of the Baroſcope, or Quick-ſilver Weather-Glaſs.

AND here it may not be amiſs in the firſt place, to ſhew you my Opinion concerning the Reaſons of that different weight of Air which is now generally believ'd, (and that with good Reaſon too) to be the cauſe of the Quickſilvers riſing againſt fair, and falling againſt foul Weather: Now the Reaſons or Cauſes of this, I take to be principally two; the one is the Dilating and Contracting of the Air; and the other is the Airs being empty of light Vapours, and ſometimes filled with them.

That the Air is capable of Contraction and Expanſion, is plainly apparent by its dilating with Heat, and contracting by Cold in the Bolt-head of a Thermoſcope, or Water Weather-Glaſs.

Now if the Air be Contracted into a leſs room, by what cauſe it will, the Adjacent Air flows in to make good the Level of the *Atmoſphere*, and ſo by the

the Addition of more Air, the Cylender which bouys up the *Mercury* in the *Weather-Glaſs* becomes heavier, and by conſequence makes the *Quickſilver* riſe; and though in Summer-time it may be thought that the Heat we feel ſhould rather Expand than Contract, yet in this we may be deceived; for though the Air be Hot juſt at the Earth by the Sun's Reflection, yet the upper Regions are ſtill as Cold as ever, witneſs the *Snow* which continues all the Year round on the Tops of ſome very high Mountains, and ſo the Air may very well be accidentally contracted in the hotteſt time of Summer, as well as in the coldeſt Winter, and be one occaſion of the Airs being then as heavy in dry Weather, as in the faireſt time of Winter.

And as the Air is made heavier by Contraction, ſo 'tis made lighter by Expanſion; for when its Body is rarified from what Cauſe ſoever, the Swelling thereof cauſes the higheſt part to flow off; or, as I may ſay, run down on thoſe Parts of the *Atmoſphere* that are below it, by which means the *Cylender*, or Pillar of it that preſſes on any Place becomes lighter,

lighter, and ſo the *Mercury* in the *Baroſcope* is ſuffered to ſink down or deſcend.

And that the Airs being ſometimes full of watry Vapours, and ſometimes empty, is another and the chief Reaſon too of the *Quickſilvers* riſing and falling, is manifeſt from this Principle in *Philoſophy*, That whatever Riſes up and Swims in any *Medium*, muſt Bulk for Bulk be lighter than the *Medium* by which it is ſuſtained: Hence it follows, that all kinds of watry Vapours muſt be lighter than the Air, elſe they could never riſe up therein, nor be ſuſpended there, till by another Principle in Nature they are made to deſcend in Rain or Snow. Now if Water thus Rarified be ſpecifically lighter than Air, then 'tis plain, that when the Air is filled therewith, it muſt become leſs weighty than it was before: As a Glaſs filled with half Water and half rectified Spirit of Wine, a much lighter ſubſtance, ſhall not weigh ſo much as when fill'd with all Water; ſo the Air is always lighteſt in wet Weather, becauſe the Spaces above us are then full of Vapours, much lighter

er than the Air is, and by consequence the Body of Air and watry Particles mixt together, must weigh less than if the whole were only an unmixt and pure Air.

On the contrary, when the Air is dry and free from being thus fill'd with watry Vapours, it must then be most heavy at such times: Indeed we may perceive many large white and curled Clouds sailing aloft over us, but these are only a Collection of some few Vapours in the very upper Region of the Air, the Spaces below being in the mean time very little, or not at all filled therewith; whereas in very wet Weather, when the Glass is low, and the Air very light, we see not only the upper Region full of compacted Vapours, but find also the whole *Atmosphere* even down to the Surface of the Earth filled therewith; as is manifest by the Sweating of Stones, and other tokens of the Airs extream Humidity, and by consequence the fuller of light matter, the Spaces above us are, the less will the Weight be that presses downward; and for that Reason

Reaſon the Glaſs in the wetteſt Weather always ſinks loweſt.

This being premiſed, I come to the more particular Uſes of the Glaſs; and firſt, you may perceive by what has been ſaid, That the Glaſs gives a very good account of the Temper of the Air as to its Moiſture or Drineſs, the Moiſture thereof, or its Fulneſs of watry Vapours, being always proportionable to the lowneſs of the *Quickſilver*, and every Degree of Sinking is an argument of the Airs being filled more and more with Moiſture, and the lower its Station, the more full of Moiſture the Air ſtill is; and you ſhall always obſerve, That the lower the *Quickſilver* deſcends, the more liſtleſs and out of order Men's Bodies are, becauſe the Air is then full of that which is diſagreeable to the Nature of Man, who was not made to live in a Watry Element: and therefore the more Watry the *Medium* is in which he lives, the more is his Nature diſturbed at it.

On the contrary, The higher the *Quickſilver* is, the drier ſtill is the Air; and by conſequence Men's Bodies are then found to be more Brisk and Lively, becauſe the *Medium* in which they live and move, is free from what their Nature abhors; ſo that by the *Weather-Glaſs* may be known in great part, whether the Diſorder and Melancholy, or the Periodical Pains and Aches to which we are ſometimes unavoidably ſubject, is really occaſioned by a new bodily Diſtemper or not; for this happening when the *Quickſilver* is low, may be judg'd to be occaſioned rather by the Air, and by conſequence will go off naturally of it ſelf when the *Quickſilver* riſes; a too moiſt Air has ſtranger Effects on Men's Bodies, than is generally taken notice of by them that underſtand not the Reaſon from whence it proceeds.

In the next place obſerve, That as the *Baroſcope* Predicts only fair and foul Weather, ſo that you may be the better directed which of theſe to expect; you muſt ſtill note the riſing and falling of the *Mercury*; for its riſing in any

any part of the Glaſs, betokens a tendency to fair, as its falling down foreſhews an inclination to Rain and Wet: As for the Words engraven on the upper part of the *Regiſter Plats*, they are then only to be noted when the *Mercury* removes from Changeable upwards, and thoſe on the lower part are to be noted only when the *Quickſilver* falls from Changeable downward.

In other Caſes the Words are of nō Uſe; for if it is Riſing in any part, foreſhews a Tendency to be Fair, and its Falling in any part, a Tendency to foul Weather; then it follows, that if it fall from ſettled Fair to Fair, it may yet Rain a little, though the *Quickſilver* ſtill ſtands as high as Fair; the like may be ſaid, if it riſe from the Word, much Rain to Rain; for though its Riſing betoken a Tendency to Fair, yet ſince 'tis ſtill ſo low as the Word *Rain*, there may be yet be ſome Wet *Weather*, though not ſo much as there was before the *Quickſilver* began to riſe.

But if the *Mercury* mount upwards from Changeable, then will the *Weather* for the moſt part be ſuch as the Words

Words in the upper part of the Regiſter Plates Import; and if from Changeable it falls down, the *Weather* likewiſe will be much the ſame, as the Words found in that Part do expreſs; but in the *Mercuries* riſing up to Changeable when 'tis below it, or falling when 'tis above it, the Words as I ſaid before, ſignifie nothing.

If the *Mercury* riſes very high, the *Weather* will continue Fair, ſo long as it ſtands at that pitch, and you will not find the *Weather* change much, till the *Mercury* falls down a good Space lower: So likewiſe when 'tis fallen down very low, you muſt expect Wet *Weather* during all the time of its ſo continuing; in both theſe Particulars you will be certain, provided the *Wind* and the *Moon* Concur.

For both the *Wind* and the Changes of the *Moon* are to be well obſerved in order to make the truer Prediction: And firſt, for the *Wind*; this is found to be of very great Moment; for if the *Glaſs* fall, and the *Wind* ſit in thoſe Quarters, from whence much *Rain* is obſerved uſually to come; as with us about

about *London* are the *South* and *South-weſt*, then 'tis not to be doubted but *Wet* will follow. On the contrary, if the Glaſs riſe when the *Wind* blows from a dry Quarter of the *Heavens*; as with us are the *North* and *Eaſt*, then 'tis a hundred to one but the *Weather* will be Fair; but if the *Glaſs* riſes, and the *Wind* be *South*, the Caſe is doubtful: So alſo if it falls, and the *Wind* be *North*, for then it often happens that the *Weather* does not prove always ſuch as the Riſing and Falling of the *Glaſs* Predicts.

As to the *Moon*, 'tis well obſerved, That the *Weather* is generally inclinable to *Moiſture*, about three Days before, and three Days after, both the *New* and *Full Moon*; if therefore the *Glaſs* Falls, the *Wind* be *South*, and the *Moon* near the *New* or *Full*, the certainty of *Rain* is ſtill much the *greater*.

If the *Mercury* be high in the *Summer-time* when the *Weather* is *hot*, and does of a ſuddain fall down a pretty conſiderable Diſtance, then certainly expect great and ſudden *Storms* of *Rain* and *Thunder* to follow ſoon after.

When the *Glaſs* is Riſen very high in *Winter*, and the *Wind* ſits then

North and *East*, it certainly presages *Frost* to ensue, and the same will continue as long as the *Mercury* stands thus High; but when you see it begin to sink somewhat considerably, then be assured a *Thaw* will quickly follow.

If in a *Frost* the *Air* becomes Overcast, and the *Quicksilver* Rises of a suddain yet higher, when it had stood high for a time before, then look for *Snow*, for the Cold above, which is the Cause of *Snow*, causes also the *Air* to become more heavy by Condensation.

If the *Glass* Rise and Fall but a little, or it be unsettled in its *Motion*, it then argues an unconstant Season, and the *Weather* will not then long continue in one state; the like happens when it is about the Word *Changeable*, or *Uncertain*, for then no true Guess can be made what the *Weather* will be.

The *Mercury* is always observed to be lowest in extream high and strong Winds, that happen when the Air is full of Moisture; but the Glass does no way predict Winds before-hand, for the extreme low-

lowneſs of the Quick-ſilver happens only at the very Time the Wind Blows, and as ſoon as the Wind Ceaſes the *Mercury* is then found to riſe apace, but ſuch a Riſe that immediately follows Storms, are no ſigns of fair Weather, except it riſes much higher than it was at the Time of the Wind's beginning to blow.

Note, That when Wet is predicted by the Glaſs, or by any other Sign or Token, it generally begins to rain either when the Moon is due South, or elſe when the Sun comes to be upon the ſame Quarter from whence the Wind blows; and if it rains not at the Time of the Moon's Southing or Northing, nor when the Sun and the Wind comes together, then 'twill hardly rain till the ſame Times do again return; which is a good Note in time of Harveſt, and very ſeldom fails, though it ſometimes may.

Note alſo, that moſt great Changes of the Weather happen with us, either at the New full Moon; and if the Weather change not then, 'twill hold on as it is till the next New or Full Moon comes: Froſt generally breaks at the Changes,

when it does break, and 'tis commonly at the Change or Full that Rain comes, after a dry Seaſon has long continued.

An Addition of ſome Natural Predictions *of* Fair *and* Foul Weather: *And firſt of* Fair Weather.

THe much hooping of Owls, after Sun-ſet, in the *Summer*-time, and in the Night alſo, foreſhews a fair Day to follow.

Swarms of little Gnats and Flies, ſporting themſelves together, in the Evening, is a certain token that the Day following will be fair.

If the Sun ſet red in the Evening, and the Place be free from Clouds, and the next Morning riſes clear and bright; theſe are good tokens that the Day will be fair.

The Soaring of Kites aloft in the Air, is a Sign of dry and hot Weather.

When

When the Bat-Mice are ſeen to fly to and fro, in the Evening, it ſhews that the next will be a fair Day.

If, in the Morning, Miſts deſcend from the Hills, and ſettle in the Vallies, 'tis a Sign that the Day will be fair.

If it rain in the *Summer*, and Horſes and Kine do thereupon leave off Feeding, 'tis a certain Sign the Rain will not continue long.

Crows, if they caw or cry early in the Morning, with a loud and clear Voice, it ſhews that the Day will be fair.

Signs of Rain *and* Wet Weather.

IF, in the Evening, the Sun ſet behind a dark black Cloud, and her Body appear alſo greater at that Time than uſual, it certainly betokens Wet the next Day.

If Water-fowl waſh themſelves much and dive more than uſual under Water, and alſo flutter and clap their Wings,

and oil their Feathers more than uſual, 'tis a Sign of Rain.

If Toads are, in the Evening, found leaping in the Paths or High Ways, or if the great black Houſeleſs Snails are found creeping about more than uſual, it foreſhews Rain.

An unuſual Circle of Light about the Moon or Stars, when no Miſt or Fog appears below, is a *Sign* of Rain ſoon to follow.

If the Sun, at her firſt riſing, or ſome Time after, ſhine wateriſh, that is, paler than ordinary, 'tis a Sign of a wet Day, eſpecially if the Air be ſoon after obſcured with thick Clouds.

If, in the *Summer*, in a fair clear Day, you perceive the Clouds to gather of a ſuddain on all Sides, and appear black and curled, then prepare your ſelf for Storms of Rain and Thunder ſoon after.

Hoggs crying in an unuſual manner, and running unquietly up and down, with Litter in their Mouths, foreſhews Rain and Storms at Hand.

If Crows cry much in the Evening, 'tis a Sign of Rain the next Day.

Any

Any of theſe, or the like Signs, happening in the *Summer* time, will, if the Baroſcope concur, help you to make the more certain Gueſs at what Weather will after enſue, eſpecially if the Glaſs be at *Changeable* and *Uncertain*, for then, by theſe you may the better gueſs at what Weather will follow. Some particular Places have alſo Signs of Rain and fair Weather, which others have not, which obſerved, together with the Glaſs, may make your Gueſs more certain than they can otherwiſe be; the Nature of Countries alſo differ, for whereas in *England*, eſpecially near *London* and the Southern Parts, a South Wind always brings moſt Rain, and a North or Eaſt Wind dry Weather; on the contrary, at *Edenburgh* it *Scotland* a South Wind brings the faireſt Weather, and a North or North Eaſt the greateſt Wet; theſe things conſidered, every Man that lives in Countries which differ in Temper from that for which theſe Rules ſerve, ought to frame Rules to himſelf, by obſerving the Changes that follow the Glaſs's Riſing and Falling, the Change of the Wind, and the Southing of the Moon. *Note*,

and oil their Feathers more than uſual, 'tis a Sign of Rain.

If Toads are, in the Evening, found leaping in the Paths or High Ways, or if the great black Houſeleſs Snails are found creeping about more than uſual, it foreſhews Rain.

An unuſual Circle of Light about the Moon or Stars, when no Miſt or Fog appears below, is a Sign of Rain ſoon to follow.

If the Sun, at her firſt riſing, or ſome Time after, ſhine wateriſh, that is, paler than ordinary, 'tis a Sign of a wet Day, eſpecially if the Air be ſoon after obſcured with thick Clouds.

If, in the *Summer*, in a fair clear Day, you perceive the Clouds to gather of a ſuddain on all Sides, and appear black and curled, then prepare your ſelf for Storms of Rain and Thunder ſoon after.

Hoggs crying in an unuſual manner, and running unquietly up and down, with Litter in their Mouths, foreſhews Rain and Storms at Hand.

If Crows cry much in the Evening, 'tis a Sign of Rain the next Day.

Any

Any of these, or the like Signs, happening in the *Summer* time, will, if the Baroscope concur, help you to make the more certain Guess at what Weather will after ensue, especially if the Glass be at *Changeable* and *Uncertain*, for then, by these you may the better guess at what Weather will follow. Some particular Places have also Signs of Rain and fair Weather, which others have not, which observed, together with the Glass, may make your Guess more certain than they can otherwise be; the Nature of Countries also differ, for whereas in *England*, especially near *London* and the Southern Parts, a South Wind always brings most Rain, and a North or East Wind dry Weather; on the contrary, at *Edenburgh* in *Scotland* a South Wind brings the fairest Weather, and a North or North East the greatest Wet; these things considered, every Man that lives in Countries which differ in Temper from that for which these Rules serve, ought to frame Rules to himself, by observing the Changes that follow the Glass's Rising and Falling, the Change of the Wind, and the Southing of the Moon. *Note*,

Note, If the latter End of *February* and the Beginning of *March* be conſtantly Dry, it betokens a very Dry *Summer*. Alſo a hard Froſty and Snowy *Winter* makes the Year following to be very Plentiful and Healthy, but a Warm and Moiſt *Winter* makes the *Summer* after to be very ſickly.

Some Uſes of the

Spirit Weather-Glaſs.

THE ſuddain Riſing of the Spirit in the Day, in *Summer*, foreſhews an immediate Approach of Thunder and Storms of Rain, and in *Winter* Snow.

If it riſes much in the Day and falls but little in the Night, then expect, the Day following, exceſſive Heat, if not Thunder and Storms.

If

If it riſes never ſo little in the Night-time, expect next Day either Rain or Snow, as the Seaſon is.

If it riſes no more in the Day than it falls in the Night, 'tis a Token that the Air is Temperate, as to the Heat and Cold.

If it falls in the Day-time, and the Weather be fair, expect a Froſt the next Night. The like happens alſo generally when the Liquor is very low.

The more it riſes or falls at any Time the more remarkable will that Change of Weather be which follows.

All the other Uſes of it are only to ſhew the preſent Temper of the Air, as to Heat and Cold, and farther than this my Experience has not as yet led me, neither by Enquiry do I find any other uſeful Obſervations made on them.

I ſhall only add, That theſe Glaſſes might be made as ſtrong as the Tube of a Quick-ſilver Weather glaſs, provided the Ball be proportionable to the Bore only. It may be, if the Glaſs were thicker, they would not move ſo nicely; but this would not ſignify much, becauſe little Judgment can be made from ſmall and little Alterations.

Juſt

JUſt when the laſt Sheet was ready to be printed off, that which follows was communicated to me by Mr *Watſon*, the Perſon before-mentioned in this Work, which in reſpect of its Nature, being not only plain and uſeful, but alſo free from all Objections that Tables may be liable to, I have thought fit to add it hereunto, upon his Recommendation, and in the Words penn'd by himſelf.

SIR.

I *Rather communicate this to you, becauſe many Gentlemen have the Convenience of Places fit for this way of Obſervation, which I take to be the moſt exact Way yet found to adjuſt a Pendulum Clock well. If you think it may be ſerviceable to thoſe that are the moſt exact and curious in Time-keeping, you may do well to inſert it in that laborious and curious Tract of the* Equation of Natural Days, *that you are now publiſhing. I am,*

Your real Friend
and humble Servant,

S. W.

The Way of finding how much a Pendulum Clock *has gained or loſt in a Day, Week or a Month, to the nicity of Two or Three Seconds*, &c.

N.	h.	'	"	N.	h.	'	"	N.	h.	'	"
1	0	3	56	12	0	47	11	22	1	26	30
2	0	7	52	13	0	51	7	23	1	30	25
3	0	11	48	14	0	55	2	24	1	34	21
4	0	15	44	15	0	58	58	25	1	38	17
5	0	19	39	16	1	2	54	26	1	42	13
6	0	23	35	17	1	6	50	27	1	46	9
7	0	27	31	18	1	10	46	28	1	50	5
8	0	31	27	19	1	14	42	29	1	54	1
9	0	35	23	20	1	18	38	30	1	57	57
10	0	39	19	21	1	22	34	31	2	1	53
11	0	43	15								

TAke a Piece of thin Braſs, and file therein a Slit or Notch, about half a quarter of an Inch deep, but ſomewhat wider at the Top than at the Bottom, as thus  , knock the End of it into ſome Poſt in your Back-ſide, or elſe in ſome Window, that ye think convenient; then look through the Notch at any Star of the firſt or ſecond Magnitude, and wait till the Star comes to the Edge of any Chimney, or the Side of any Houſe, and you will ſee the Star vaniſh in a Moment; then mark what your Clock is at when

when the Star vaniſhes: Then at any other Night afterwards (as the next Night, or a Week or a Month afterwards) wait for the ſame Star again till it vaniſh behind the Chimney or Houſe, as before, and then obſerve what your Clock is at, then your Clock ſhould ſhew the ſecond Time of vaniſhing ſo much ſooner than the firſt, as this Table ſhews; now the farther off the Chimney or Wall is the more exact will the Obſervation be. Let the Diſtance be Ten Yards at leaſt; let the Obſervation be made in any part of the *Eaſt*, *South* or *Weſt*, but little towards the *North Pole*, becauſe the *Polar Stars* are not ſo fit for this Purpoſe.

EXAMPLE.

Suppoſe a Star vaniſhes this Night at Nine Hours, Three Minutes and Four Seconds, by my Clock, and Eight Nights after I obſerve it again, and it then vaniſhes at Eight Hours, Thirty four Minutes and Forty two Seconds; by my Clock, againſt Eight Nights, in the Table, I find Thirty one Minutes Twenty ſeven Seconds; that is, ſo much ſooner ſhould the Star vaniſh at the ſecond Obſervation than it did at the firſt; therefore ſubſtracting 31′ 27″ from the firſt Obſervation 9h. 3′ 4″. there's left 8h. 31′ 37″, the true Time that the Clock ſhould have been at in the ſecond Obſervation; therefore ſeeing the Clock was then at 8h 24′ 32″, it has gained 2′ 55

FINIS.